UNIVERSITA' DEGLI STUDI DI TRENTO - DIPARTIMENTO DI ECONOMIA

CAN WE LINK CONCESSIONAL DEBT SERVICE TO COMMODITY PRICES?

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Abstract

We consider a scheme that gears service on concessional debt to changes in a country specific terms of trade index. Each country's index comprises the world prices of the same set of major commodity prices weighted by their importance in GDP for the specific country. The scheme operates by accelerating and retarding concessional debt repayments: it allows countries to postpone concessional debt service in years when their terms of trade are unfavorable, but at the expense of advancing them in years in which they are more favorable. We analyze the effectiveness of the scheme using Monte Carlo debt service simulations for 31 low income countries. Results show that modifications of this sort appear feasible and increase the flexibility of low income primary producing countries without posing substantial costs or risks to the lender. Only countries heavily dependent on primary commodity exports or imports of major commodities (energy sources and grains) are likely to qualify for use of this instrument. A price instrument of this sort allows for a timely intervention in the event of a terms of trade shock and avoids moral hazard.

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1 Introduction

Primary commodity markets are always volatile. In the non-oil sector, this volatility is compounded by a secular tendency for prices to decline. Low prices, associated with chronic excess supply resulting from over-investment, tend to be highly persistent. Many Low Incomes Countries (LICs) have borne the brunt of all three effects over the past two decades. Adverse terms-of-trade movements have significant adverse effects on LIC economic performance. They directly reduce real income and the resources available for investment and consumption (IMF 2003). Adverse developments in a country's terms of trade negatively affect economic growth (Collier and Dehn 2001; Chauvet and Guillaumont 2001; Combes and Guillaumont 2002). Furthermore, adverse terms of trade shocks have been cited as a major contributing factor to the buildup of debt in many LICs (Brooks et al. 1998; IMF 2003).

The risk of debt distress in these countries primarily increases not so much as the result of increases in the debt burden itself, but due to a deterioration in capacity to pay. While debt levels in low income countries are fairly stable, these countries experience high volatility in exports (Cashin and McDermott 2002; Easterly 2003; Gilbert 2004; Dehn 2004). Because schemes to smooth export earnings have, in general, proved unattractive, unsuccessful or financially unviable[1], "unsmoothing" concessional debt service can be a viable alternative (World Bank 2003). Attempts on the part of the international financial community to relieve these countries of their debt burdens by means of continuous restructurings and debt relief have seen only limited success – see Sun (2004). This raises the question of whether changes in the repayment structure might both provide *ex ante* insurance and increase countries' flexibility in meeting their debt service operations, and, in doing so, promote enhanced risk sharing between LICs and the international community.

There has recently been a number of attempts to design schemes using real indexation of concessional lending. Three modes of operation have been considered recently by the World Bank (see World Bank 2005):

[1] Price stabilization and compensatory finance have been used to smooth export revenues. International commodity agreements, which set out to stabilize prices, are discussed in Gilbert (1987, 1996). Compensatory financing schemes (including the EU Stabex and Flex programs, and the IMF Compensatory Finance Facility) are reviewed in Tabova (2005).

- Moving concessional lending from a dollar to an indexed local currency basis – see Hausmann and Rigobon (2003), and Vostroknutova and Yi (2005). This would protect LICs against adverse movements in their real exchange rates.
- Gearing repayments on concessional loans to countries' growth rates – see Tabova (2004) and Vostroknutova (2005). This procedure would directly link repayments to ability to repay.
- Linking repayments to countries' terms of trade defined in germs of the world prices of the goods they export and import – see Gilbert and Tabova (2004).

Despite their different formulations, these three sets of proposals have much in common. For example, an adverse terms of trade shock is likely to worsen a country's real exchange rate and result in a slower rate of growth – see Cashin *et al.* (2003, 2004). The major differences between the schemes relate to the extent to which the selected criterion correlates with ability to pay, the extent to which it is inclusive across countries, the timeliness of the assistance and the incentives (in relation to participation, policy and reporting) that the scheme generates.

Our focus is solely on the third of these groups of schemes, in which LIC debt service is geared to countries' terms of trade. The objectives of the schemes we investigate are to reduce the extent that terms of trade shocks imperil debt sustainability with the aim that they impose as light a constraint as possible on countries' economic growth. The repayment capacity of primary producing countries with low incomes is highly sensitive to adverse movements in the international prices of the commodities they export. Many countries are also highly sensitive to the prices of the major commodities they import, typically energy and grains.

A number of HIPCs which have reached the HIPC "completion point"[2] have found that, despite the agreed debt reductions, their debt levels remain unsustainable, either because of falls in the prices of their commodity exports or because of higher oil import prices. A 2002 IMF-World Bank review reportedly concluded that one of the two main causes of

[2] The HIPC initiative envisages countries progressing from a "decision point" to a "completion point". At the decision point, creditors commit on sufficient debt relief to leave the remaining debt sustainable, relative to the information available at that time. Movement from the decision point to the completion point, when the agreed debt reduction takes place, is conditional on the country establishing a track record by implementing poverty reduction and other policies to which they committed at the decision point.
See http://www.worldbank.org/hipc/about/flowchrt4.pdf

deterioration of debt indicators for HIPC countries in 2001 was “lower export earnings owing mainly to declining commodity prices”. Lower average exports accounted for over 50% of the deterioration of the HIPC debt service indicators and export prices declined by an average of 4.8% for HIPC countries which experienced a deterioration in debt indicators against only 1.1% for those which did not (IMF and IDA, 2002, pp. 24-7). We draw two conclusions from these observations. The first is that terms of trade shocks are indeed important in determining the capacity of a low income country to service its debt. The second is that sustainability is impaired by prolonged or severe adverse movements in the terms of trade as much as to their level – here we are primarily concerned with vulnerability to bad outcomes.

We look at terms of trade defined as the world prices of country-specific baskets of standardized commodities exported and imported. This has two advantages. First, no LIC has any significant market power and so there are no moral hazard problems of the sort which arise when governments have some control over a variable which determines debt service payments. Second, world prices are known without any lag and a scheme based on such prices is able to moderate debt payments in a timely manner. There are also possible disadvantages. First, because of transport costs and grade differentials, the prices at which a country exports or imports may only be moderately well correlated with the international price of the commodities in question – see Gilbert and Tabova (2004). Second, quantity variation may be as important a determinant of a country’s export revenue variability as price variation – see Lim (1987, 1001) and Gilbert and Tabova (2004). Third, reliance on a terms of trade trigger limits applicability of the scheme to countries with high commodity concentration in exports and imports. In the final connection, we note that commodity concentration tends to be a function of the level of development and size, and so effectively all except the largest LICs will tend to qualify under a scheme of this sort.

Commodity prices have exhibited a downward trend relative to the prices of manufactures, and more recently also in nominal terms, for at least a century and probably longer (Grilli and Yang, 1988). However, the pace of this fall varies from commodity to commodity, and, even more markedly, from one decade to another (Gilbert, 2004). This negative trend is generally regarded as resulting from the effects of productivity-enhancing technical change in production and intermediation processes, which, in the case of manufactures, is partly reflected in higher product quality and specifications (Lipsey, 1994). It seems likely that most primary prices will continue to fall relative to manufactures prices, but there is no reliable means of knowing by how much and which commodities, if any, will be exceptions to this pattern.

This variable trend poses problems for any attempt to link debt service payments to commodity prices. Adjustment of a country's debt service in relation to secularly declining terms of trade would amount to a substantial element of debt relief instead, as intended in the schemes we discuss, of an altered time pattern to facilitate eventual full repayment. It would also reduce incentives for the country to diversify into higher value activities. For these reasons, we look at schemes which moderate debt service payments in relation to variations in countries' terms of trade around trend and not to the trend itself.

Any scheme must necessarily have three components:

a) an index, the value of which will trigger either an upward or a downward adjustment of debt service in the year in question, or an option for the government of the indebted country to make such an adjustment;
b) a formula which translates values of the index into revised debt service payments in the circumstances that such adjustments are triggered;
c) an arrangement by which the lender is compensated for the resulting repayment variability.

We discuss each of these in turn. Section 2 looks at the definition of the index. Section 3 looks at the design of schemes aimed at using debt service to moderate the impact of commodity price shocks. Section 4 describes the simulation methodology and the design of the scheme we test. Section 5 reports the results. Section 6 looks briefly at financing issues, and section 7 concludes. The appendix shows how changes in the terms of trade index relate to development objectives.

2 The Index

The objective is to define a country-specific index which is comparable across low income countries so that, based on the value of their indices, all debtor countries would be treated in an identical manner and which is directly interpretable in terms of other economic variables. A country's terms of trade may be measured in either of two ways:

- the ratio of the country's export unit values to its import units values;
- an index of the world prices of the goods the country exports and those it imports.

Unit values depend on accurate export and import data and are published with a considerable lag. Because there may be a suspicion that national statistical offices are not entirely free of government influence, there may be a concern that reported unit values misrepresent actual prices in a direction favorable to governments. Use of world prices avoids these two problems.

It is necessary to decide what prices to include in the terms of trade indices. We confine attention to commodities with clear and well-defined world prices. The list of candidate commodities is as follows:

- agricultural exports: cocoa, coffee (distinguishing between arabica and robusta), cotton, maize, rice, rubber, soybeans, sugar, tea, wheat;
- energy exports: coal, crude oil, natural gas;
- metal exports: bauxite, copper, gold, lead, nickel, silver, tin, zinc;[3]
- grain imports: maize, rice and wheat;
- energy imports: coal, crude oil, natural gas.

The requirement that there be a clear world price forces the omission of many minor commodities, but also a number of important commodities, in particular iron ore and oils. For reasons we explain below, metals are omitted from the index which we eventually adopt.

In defining the index, we need to make decisions on three issues:

a) the structure of the index,
b) the choice of weights, and
c) the timing of the prices which enter the index.

[3] Metals exports are measured as the value of the metal content of mine production, it is being assumed that consumption is negligible.

Consider the structure question first. Suppose that a total of m export commodities is distinguished. Let P_{it} be the world price of the ith commodity in year t. Let $\overline{P}_{it}$ be the base price which may either be a single average price over the past or a moving average of past prices, e.g. $\overline{P}_{it} = \frac{1}{n}\sum_{s=t-n-1}^{t-1} P_{is}$. In what follows, we set n = 4. We can then define the deviations $\ln p_{it} = \ln\left(\frac{P_{it}}{\overline{P}_{it}}\right)$ from the (four year) moving average. The proposed export price index for country j is $\ln q_{jt} = \sum_{i=1}^{m} w_{ijt} \ln p_{it}$ where w_{ijt} is the country-j weight of commodity i in year t.

We turn now to the weights w_{ijt}. These are chosen to reflect:

- the relative importance of different commodities in country j's exports, and
- the importance of exports for the country.

The first of these criteria is unexceptionable, but it is important to be aware that export shares evolve markedly over time as countries diversify into new products or as older industries decline. The second criterion is required in order that the impact of price movements should be the same across countries with different export shares – the impact of a fall in the price of a major commodity will depend not only on the country's export concentration but also on the share of exports in national income. For these reasons we base the weights on the value share of each export in the country's national income. However, in order to reflect the evolution of these value shares over time, we take a moving average of past value shares (we use the previous four years for symmetry with the price moving average). The index is easily extended to import commodities by letting w_{ijt} be the pseudo-share obtained as minus (the same moving average of) the ratio of imports of these commodities to national income. The negative sign reflects the fact that rises in import prices contribute to a deterioration of the country's terms of trade.

Finally, there is the issue of timing. Depending on contracting arrangements, world prices will affect a country's import and export prices either immediately or with a delay of up to one year. Many commodities are bought and sold on a forward basis, and, to that extent, prices received or paid will relate to world prices at the contracting rather than the delivery date. It is difficult to know how important are these arrangements on an *a priori* basis. We therefore decide whether or not to lag prices on the basis of regressions to be discussed below.

The index concept we use is close to that of a Deaton-Miller index (Deaton and Miller, 1995; Dehn, 2004). However, it differs from standard Deaton-Miller indices in that the sum of a particular country's weights $w_{jt}^{*} = \sum_{i=1}^{m} w_{ijt}$, equal to the commodity share in the country's national income, will be less than unity, and for many countries considerably less than unity. The value of the index may be interpreted as the percentage gain or loss in national income resulting from a change in the country's export or import prices, relative to their recent moving average, if in the absence of any change in export or import quantities. Since production and consumption will respond to price changes, the index over-estimates the actual gain in the same way that Laspeyres consumer price indices overestimate changes in the cost of living.

We have data on 67 LICs from 1970 to 2001, but for many of these countries the data are insufficient to allow us to calculate index values. There is a number of reasons for this:

- Some countries, in particular in central Asia, only became independent nations in the nineteen nineties.
- Other countries lack reliable national income data – this is particularly true of countries which have seen major civil conflict.

This leaves 37 countries for which we have complete index data over the period 1983-2001 and a further 19 for which we have partial information.

In relation to timing, we choose whether or not to lag prices in the index on the basis of a preliminary growth regression. We define separate indices for agricultural export prices $\ln q^{ax}$, metals prices $\ln q^{mx}$, energy export prices $\ln q^{ex}$, energy import prices $\ln q^{em}$ and grains import prices $\ln q^{gm}$. The overall index is the sum of the three export sub-indices less the sum of the two import sub-indices. Preliminary (pooled OLS) regressions (reported in the appendix) indicate that:

- agricultural export and energy import prices affect growth with a one year lag;
- energy export prices and grains import prices affect growth contemporaneously and with one year lag;
- the effects of energy import prices are poorly defined;

- metals export prices always enter incorrectly signed.
- only energy export prices have much statistical significance.

Based on these results, we define a modified index with weights as specified in Table 1.

Table 1 Index Composition and Lag Structure		
	Current Year	**Previous Year**
$\ln q^{ax}$	0	1
$\ln q^{mx}$	0	0
$\ln q^{ex}$	0.5	0.5
$\ln q^{em}$	1	0
$\ln q^{gm}$	0.5	0.5
The table reports the weights of the current and previous year's prices in the terms of trade indices.		

It is easy to think of reasons why metals export might give rise to discrepant results, although it is unclear to what extent this is simply *ex post* rationalization. The vast majority of mining (in terms of output) is under the control of quoted mining companies. Further, employment is on a salaried basis. This contrasts with agricultural commodities which, in developing countries, are typically produced either by smallholders or larger domestically owned and controlled farming enterprises. But by contrast with the energy sector, mining rents are not so large as to offer many governments large royalty incomes. We therefore conjecture that the primary impact of changes in metals prices is on the profits of the mining companies and not on either producer incomes or governmental revenues. In what follows, we exclude metals exports from the commodity price index.

Table 2 gives summary statistics for the index values for these countries ranked by variability, using the index as modified above. Focusing on those countries for which we have data over the complete sample 1983-2001, an oil exporter, the Republic of Congo exhibits the greatest variability. It is followed by Guyana, whose exports are dominated by bauxite (excluded from the index) sugar and rice; and Sao Tome and Principe and Cote d'Ivoire, whose exports are dominated by cocoa. These three countries also show high dependence on imported oil and grains. Figure 3 graphs the index values for these four countries over the period 1982-2001.

The more diversified Asian economies, such as Bangladesh, Lao PDR, and Nepal, tend to be close to the bottom of the table, although Sri Lanka has experienced significant variability and is in the upper half of the volatility ranking. Figure 4 charts the evolution of the index for these four countries. A remarkable feature of Figure 4 is the decline in index volatility since around 1990, perhaps reflecting increased diversification and reduced commodity dependence. Figure 5 looks at four African agricultural exporters (Burundi, Ghana, Kenya and Uganda). Here, there is no evidence of volatility decline. Furthermore, the four lines move closely together reflecting the importance of both coffee exports and oil imports for these economies. Finally, Figure 6 shows the index values for three Latin American and Caribbean countries (Haiti, Honduras and Nicaragua). The coffee cycle is again evident for Honduras and Nicaragua.

3 Moderating Concessional Lending

3.1 Principles and mechanics

A particular concessional loan will define a set of scheduled payments S_t^* over a time period $t = 1, \ldots, T^*$. Some of these repayments (those falling due in the grace period) may be zero. Define the total amount due to be repaid (the scheduled "debt") at date t on the basis of the scheduled payments as $D_t^* = \sum_{j=t+1}^{T^*} S_j^*$. The proposed scheme would substitute a set of revised payments S_t, $t = 1, \ldots, T$, where T is the revised debt horizon. Extension or shortening of the horizon from T^* to T is intended to facilitate full repayment for the countries that have accumulated arrears at the end of the period and to avoid over-payment once the debt has been fully repaid. In the long term the scheme would be neutral for the lender in the sense that all scheduled repayments will eventually be made, i.e. $D_0 = \sum_{j=1}^{T} S_j = \sum_{j=1}^{T^*} S_j^* = D_0^*$.[4]

Define $X_t = S_t^* - S_t$, the difference between the scheduled and actual payments in period t. We can think of this payment, if positive, as being postponed and would count towards the debt service balance at the country's account with the lending institution; and if negative as being used to accelerate the repayment of the loan and would reduce the concessionality of

[4] An alternative would be to insist on neutrality in terms of the net present value of flows, i.e. $N_0 = \sum_{j=1}^{T} \frac{S_j}{(1+r)^{j-t}} = \sum_{j=1}^{T^*} \frac{S_j^*}{(1+r)^{j-t}} = N_0^*$. The two expressions become equivalent at a zero interest rate.

the loan in the sense that it would be repaid earlier than scheduled (shortening the maturity of the concessional loan).

The most simple type of scheme defines a number of alternative payment regimes. In the simple three regime case, a particular period *t* may be classified as either normal *N*, adverse *A* or propitious *P*. This classification is made on the basis of a previously agreed criterion reflecting the country's terms of trade. An adverse period is one in which, on the basis of this criterion, the country would be expected to find it difficult or costly to make available the foreign exchange to meet the scheduled debt payment. Adverse periods would allow the country to qualify for postponement of payments. A propitious period is one in which, on the basis of the same criterion, there would be more than sufficient availability of foreign exchange for this purpose. In a propitious period, the country repays a higher debt service, and in a normal period, the country would make scheduled repayments, i.e. $S_t = S_t^*$ so that $X_t = 0$. The use of a normal period in the scheme (defined within a band) is based on the principle that any scheme should aim to cope only with exceptional and not normal price movements, either because large shocks to prices have disproportionate effects (Collier and Gunning, 1996; Dehn, 2004) or simply to limit activity.

3.2 Interventions

The interventions are uniform across countries and are set in a way that avoids over-payment of debt obligations, i.e. no country can repay more than its initial debt stock. Arrears at the end of 25 years are therefore constrained to be non-negative.

The scheme is defined by a double band and set of factors which modulate concessionary debt service in relation to the terms of trade index relative to the band. The central zone leaves debt service unaffected. This structure gives rise to four triggers determining when relief is due and when extra payments are required. The bands need not be symmetric. We set a double band, so that a Q_* (Q^*) corresponds to a negative (positive) shock, and Q_{**} (Q^{**}) corresponds to a large shock.

The period definitions (normal = N, adverse = A, and propitious = P), discussed in the previous section are tuned to reflect different shock magnitudes as follows: The adverse period in divided into a period with a negative shock A, and a period with a large negative shock A^*. Similarly, a propitious period P correspond to a positive shock, while P^* defines a period with a large positive shock. We set three ratios φ ($2 \geq \varphi \geq \theta$), θ ($\varphi \geq \theta \geq 1$) and λ ($1 \geq \lambda \geq 0$) that determine how much debt service is relieved or how much extra debt service is required in each case. Table 3 summarizes this structure. This structure satisfies the two objectives of ensuring a reasonable cost to the lender whilst offering debtor countries greater flexibility.

Table 3
Scheme Structure

Period	Index Value	Debt Service Multiple
P^*	$\ln q > Q^{**}$	φ ($2 \geq \varphi \geq \theta$)
P	$Q^{**} \geq \ln q > Q^*$	θ ($\varphi \geq \theta \geq 1$)
N	$Q^* \geq \ln q \geq Q_*$	1
A	$Q_* > \ln q \geq Q_{**}$	λ ($1 \geq \lambda \geq 0$)
A^*	$Q_{**} > \ln q$	0

The table defines the modified debt service payment (column 3) in terms of the value of the terms of trade index (column 2). See text for explanation.

In the simulation experiments reported in section 5, we need to adopt particular values for these parameters. There is neither universal agreement on what constitutes a "shock" nor any accepted measure of shock severity. This reflects difficulties in measuring the impact of these events on the wider economy. Here we are concerned about the impact of the shock and not the size of the shock itself. Our historic data shows that the average reduction in GDP is 1.7%, and the median is 0.8%. The IMF defines a 0.5% GDP shock as large.[5] Our bands are defined asymmetrically around 0.5% and 2%. The choice of asymmetric bands arises out of a wish to avoid too high a repayment rate in good years, but at the same time satisfying the requirement that arrears should not become too high. The former requirement implies relatively low values for φ and θ, while the latter requires that the bands be tighter in propitious periods than in adverse periods.

We have explored the implications of a number of different parameter choices – see Table 7. In what follows we concentrate on the results from one particular scheme that gives

[5] The IMF classifies a disaster as large if it caused direct damage of at least 0.5 percent of GDP. IMF estimates show that for developing countries between 1981 and 2000, negative price shocks led to an average to a direct loss of income of 3.5 percent of GDP (IMF 2003). Further, Collier and Dehn (2001) show that the direct income loss from negative export price shocks averaged 6.8 percent of GDP in the year of the shock.

considerable benefits to the borrowing countries without imposing a substantial cost to the lending institution. Table 4 reproduces Table 3 but gives the particular parameter settings.

Table 4
Parameters used in the Simulations

Period	Index Value	Debt Service Multiple
P^*	$\ln q > 1\%$	150%
P	$1\% \geq \ln q > 0.5\%$	125%
N	$0.5\% \geq \ln q \geq -1.25\%$	100%
A	$-1.25\% > \ln q \geq -2.5\%$	50%
A^*	$-2.5\% > \ln q$	0%

The table gives the parameter values adopted in the principal simulations reported in section 5.

3.3 Evaluation Criteria

An important issue is how potential schemes should be evaluated. The Enhanced HIPC Initiative attempts to reduce a country's indebtedness to ensure that the remainder of its debt is sustainable in relation to likely future growth – see Kraay and Nehru (2003). That judgment is based on a number of indicators, of which the principal are the flow ratio of debt service to either export revenues or GDP and the ratio of the debt stock, evaluated as the NPV of future flows, to GDP. We look primarily at the ratio of debt service to export revenues since this tends to be more variable over time than the ratio to GDP.

An important criticism of current official discussions of debt sustainability, including that if Kraay and Nehru (2003), is that they give too much focus to expected (i.e. most likely) outcomes, while sustainability is much about limiting vulnerability to bad outcomes. This suggests that sustainability should be analyzed in terms of limiting the likelihood of countries facing very high ratios of debt service to exports or GDP as much as to the expected level of these ratios. The result is to move the sustainability debate into a Value at Risk (VaR) framework – see Jorion (1997).

The VaR approach implies that we are interested in the right tail of the ratio of debt service payments to export revenues – as in VaR calculations. We can operationalize this in either of two ways:

- in terms of the proportion of years in which the ratio will exceed a predefined level; or

- in terms of the debt service to exports ratio corresponding to 95% or 99% probability, i.e. which will only be exceeded in 5% or 1% of years.

In section 5, where we discuss the results of the interventions, we adopt both measures.

4 Simulation methodology

We have performed Monte Carlo simulations over a 25-year period for a scheme of the form outlined above using a set of 31 countries. This group of countries was selected from the set of all IDA-eligible countries for which a terms of trade index could be constructed, and which in addition publish statistics on GDP, total exports and imports, with at most a few gaps, which allow calculation of the required variables in the stochastic simulation. The simulations all commence from 2002, the first year beyond the estimation sample, and extend to 2026.

4.1 Model Structure

Simulation of the future requires a model to generate GDP, exports and energy and grains imports. The model is required, not so much to generate forecasts, but to ensure consistency of the different variables (commodity prices, exports, GDP levels, etc.) in the model, and in particular, to generate the shocks which drive the stochastic simulations.

The model is designed to capture possible effects of changes in the terms of trade on economic performance and hence on debt service to exports and to GDP ratios. We distinguish between the direct and indirect effects of terms of trade variability.

- Direct effects: high export prices and low import prices make governments and commodity producers better off allowing higher real consumption and greater investment, and make consumers worse off in a symmetric manner.
- Indirect effects: these come through greater availability of foreign exchange easing funding pressures on governments and firms.

This is illustrated in Figure 1. The distinction between the direct and indirect effects is important because the introduction of flexibility into debt service acts through the second, indirect, route.

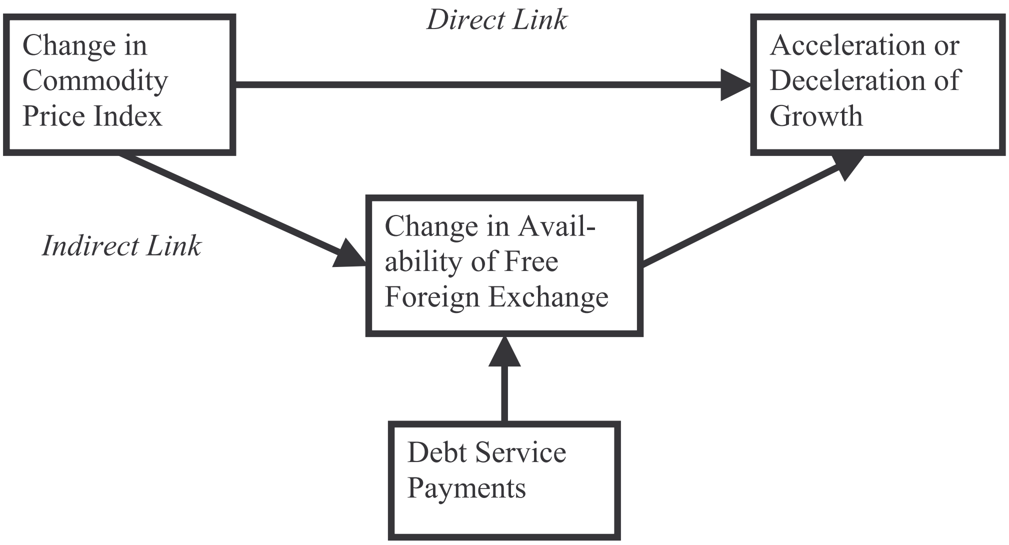

Figure 1: The Impact of Commodity Price Variability

We investigate the indirect link in two stages. We first show how variations in the index translate into what we call free foreign exchange, and then investigate whether the availability of free foreign exchange affects economic growth. A rise (fall) in export prices or a fall (rise) in import prices increases (decreases) the amount of foreign exchange available to the country for other purposes. If changes in local prices were completely in line with changes in world prices, and if there were no production or consumption responses to these price changes, the impact on free foreign exchange availability should be one-to-one. The second stage in the argument is to link free foreign exchange to growth. The implicit model here is one in which low income countries are constrained in their access to foreign exchange. If there is such a link, it can be moderated by appropriate variation of debt service payments.

We investigate these two links by a set of panel regressions.

- We regress growth on free foreign exchange availability (indirect effect) and the commodity price indices (direct effect).
- In order to complete the indirect link, we regress free foreign exchange availability on the commodity price indices.

The model structure is illustrated in Figure 2. Detailed equation specifications and some estimation results are provided in the appendix.

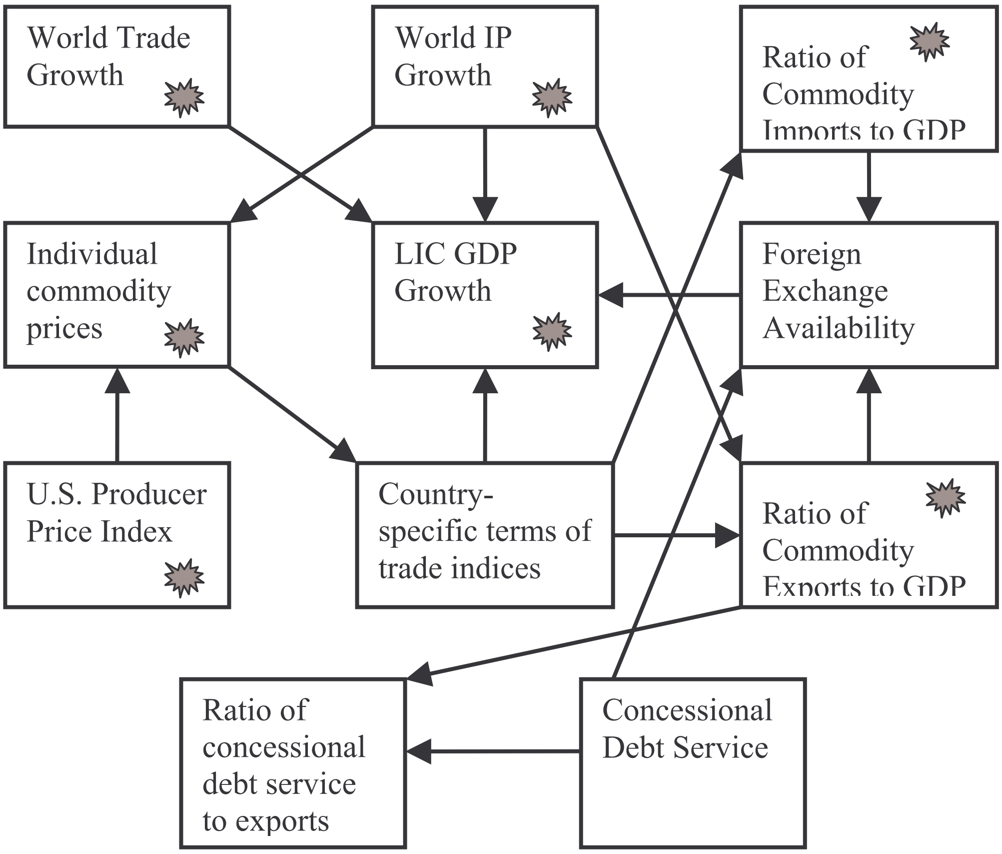

Figure 2: Model Structure

With metals excluded, the terms of trade indices are based on seventeen different commodity prices, of which six enter both the import and export indices. These prices are generated in real terms through error correction structures on the basis of the growth in world industrial production (industrial production in the industrialized countries) – see the left hand side of Figure 2. They are converted into nominal terms using an autoregressive equation for the US producer price index (all items). An "explosion" indicates a stochastic relationship.

The seventeen individual commodity prices are aggregated using constant country-specific weights into indices for each of the 31 countries we consider – see the center of Figure 2. The indices are calculated by taking deviations from four year moving averages. The model also computes indices for each sub-aggregate (agricultural exports, energy exports, grain import and energy imports) although, for simplicity, these are not illustrated in the Figure.

The terms of trade indices feed into the equation for GDP growth in each of the 31 LICs we are modeling. The equation is estimated using the panel growth methodology which imposes common coefficients across all countries. Growth is also influenced by growth in world industrial production and world trade, and by the availability of foreign exchange (the indirect link discussed above).

The right hand side of Figure 2 shows the generation of the foreign exchange availability variable which also depends on the country's level of debt service. The debt service to export ratio, in terms of which scheme performance is evaluated, is determined as the ratio of debt service, as moderated by the scheme, and the level of exports.

4.2 Simulation Methodology

We need to choose between either simulating the past or the future; and between deterministic and stochastic simulation. Simulating over the past has the disadvantage that it conditions on particular experience. Also, because concessionary debt only became important in the mid-80s, there is limited and very particular experience. For these reasons, we prefer to simulate over the future. The decision to use stochastic rather than deterministic simulations is driven by our evaluation criteria which are based around tail probabilities. Deterministic simulation is at best informative about average values. The scheme we are investigating has little effect on averages (for example, on average growth levels) since it involves changes in the timing of debt service and not changes in its levels. The cost is that stochastic simulation forces us to model shocks across the range of commodity prices and also for GDP, exports and imports for each of the countries in our simulation sample. This is demanding.

The simulation experiments are based upon a set of shock events which determine commodity prices, export and import values and GDP growth over the 25-year simulation period. The starting values for the simulation are the historic values for 2001, the final year in our estimation sample. We run 100,000 simulations over the period 2002-2026. The large number of replications is required in order to accurately define the tails of the debt service to export distributions.

We employ a bootstrap methodology to generate the shocks in the simulations – see Efron and Tibshirani (1993). This involves drawing the shocks for the simulation sample from the estimation residuals. The advantage of this procedure over the parametric alternative is that we do not need to specify the shock distributions.[6] Further, by bootstrapping the complete set of residuals for a year in the estimation sample, we automatically maintain the correlation sample structure. Since our model contains over one hundred different shocks per year, this would be computationally very difficult within a parametric structure.

The base simulation simulates an IDA-type loan with initial debt amount equal to the average concessional debt stock of each county over the final three years of the historic period (1999-2001). It assumes full repayment of this stock over 25 years, therefore, holding concessional debt service constant over the future period. In the base simulation, we therefore hold concessional debt service constant so that changes in the ratio of debt service to exports or GDP reflect changes in the denominators and not the numerator of these ratios.

5 Results

Detailed simulation results are tabulated by country in Table 6.

5.1 Activity of the scheme

Table 6 (column 1 and 2) reports the average incidences per country when the scheme would be active. Results show that on average for all countries over the 25-year simulated period the scheme would be active in 55% of the time, i.e. 14 years. Due to the relatively high oil price volatility, the largest oil exporters and oil importers would most often have the opportunity to use the scheme. Three oil exporters: Republic of Congo, Yemen, and Kyrgyz Republic, have the highest rate of use of the scheme. Cameroon, the only other oil exporter in the simulation

[6] There is a number of complicating factors. First, the commodity price equations are estimated over a longer sample than the macroeconomic equations. If a year is sampled prior to the start of the macroeconomic estimation sample, a second year is drawn for the macroeconomic shocks. here Second, some countries have short (or indeed no) samples for certain equations and so the relevant residuals are unavailable. For these country-year combinations, we sample a residual for the same year but from a different country but with a complete set of residuals. Third, the Rwandan civil ware of 1992-93 produces large outliers. These residuals are overridden for Rwanda, and the shocks are transferred to all 31 countries with a probability of 1/300. Effectively, this amounts to assuming that events of this sort are random across countries. Finally, we need to decide how to treat the fixed effects in the growth equations, Holding these constant has the result that low growth performance over the estimation sample generates low growth in the future. For two countries (Congo Democratic Republic and Sierra Leone) this result sin absurdly low GDP levels at the end of the simulation sample. The alternative possibility is to regard the fixed effects as random and to bootstrap from that distribution. That would imply no relationship between growth in the estimation and simulation samples, which also seems extreme. We compromised by assuming 50% of the fixed effects are genuinely fixed and 50% random.

set of countries ranks high in the activity list, with an average of 18 years. As expected, countries with high degree of exports concentration and heavy economic dependency on a small number of commodities would most often use the scheme. Diversified economies, such as Bangladesh, Nepal, Lao PDR, and Bhutan are at the bottom of the list with the lowest use of the scheme. A number of African countries, such as Mozambique and Tanzania, that have successfully followed diversification efforts and have seen growth of nontraditional exports, are in the lower part of the activity ranking.

5.2 Cost to the lender

The principal cost of the scheme we have considered is the unsmoothing of flows from borrowing countries to the concessional lender. Results show that the scheme would have limited impact on the lender. Table 6 provides summary statistics for the total potential cost to the lender over the simulated period. To obtain a comprehensive picture of the potential impact on the lending institution, we estimate the total cost in three ways:

- reduction in cashflow to the lender at a random year in the future. Here we take the cashflow situation at the end of the 15^{th} year of the simulated period;
- reduction in cashflow at the end of the simulated period;
- reduction in the net present value (NPV) of reflows to the lender (at a 5% discount rate).

The first criteria gives a more accurate picture of the situation in which the lender would have in its portfolio countries which at any given period would be accelerating or postponing their debt service payments. The third criterion differs from zero only because the scheme is defined to hold the dollar value of reflows constant, not its NPV.

Simulation of a portfolio of conventional concessional credits and a similar portfolio of credits indexed to commodity prices shows that the latter results in a comparative loss to the creditor of about 0.5 percent of total re-flows in expected net present value terms relative to the benchmark of full and timely repayment. The maximum simulated cost to the creditor in NPV terms is estimated at about 1.7 percent of total re-flows, while in some scenarios of commodity prices, the creditor could gain up to 0.6 percent of re-flows in net present value terms.

One reason for the limited impact is the relatively high offsetting. Oil price volatility is a major contributor to the terms-of-trade volatility in low income countries. While most low income countries import oil, a number of low income countries are oil exporters. The result is that this important volatility component has limited impact on the lender. The large common factor in agricultural commodity price cycles, however, contributes to the cash flow uncertainty. Figure 7 shows the historic price volatility of oil, cotton and coffee.[7]

5.3 Benefits to the borrower

In order to measure the benefits of the scheme to the borrowing countries we need a criterion by which to judge the success of the scheme from a country's perspective. We specified that the objectives of the scheme may be achieved by more closely matching the debt service repayments with changes in their repayment capacity. A simple and well recognized measure of this is the country's debt service to exports ratio. The debt sustainability literature has typically focused on the debt service to exports ratio. This measure also has the merit of direct comparability across countries (see for example World Bank and IMF 2001; Edwards 2001 and 2003). We propose to ask how often a country would face a high debt service to exports ratio during the period when the scheme is in place as compared to a non-intervention period. This provides a common and very straightforward method for measurement of the benefits across countries and a direct comparison between the non-intervention and the active scheme period. Currently we consider a debt service to exports ratio as high if it exceeds twice the average value of the ratio observed in the last 5 years of the historic period (1997-2001).

The simulation results are reported in Table 5 (columns 3-5). For the simulated 25-year period the average reduction of incidences with high debt service to exports ratio due to the scheme is 5.5%. The results differ markedly across countries. Of the 31 countries considered, two oil exporters (Republic of Congo and Cameroon) are seen as obtaining greatest benefit from the proposed scheme. Agricultural producers such as Burundi, Benin, Malawi, Rwanda, and Zambia also obtain sizable benefits. Overall, fifteen countries would see a reduction in their debt service to exports ratio. Estimated benefits are negative or very low in sixteen countries.

The only cost the borrower can potentially face is the loss of concessionality due to acceleration of payments in the event of a positive shock. Expressed as a ratio to the original

[7] Calculated as the intra-annual standard deviation of monthly prices.

NPV of repayments, the total proportionate loss to the creditors is equal to the weighted proportionate gains to the borrowers where the weights are the shares of each country's original debt service in total debt service of all countries in the sample.[8] On this basis, the weighted gain to the borrowers in terms of reduction of the expected repayment stream in NPV terms is 0.5% percent of the non-indexed stream.

The simulation results show that the average gain to countries which would see a decline in NPV of debt due to the scheme is 8.3%, while the average loss to countries for which the NPV of debt would increase under the scheme is only 3.8%. There are also treasury management challenges and costs associated with setting aside resources to meet increased debt service obligations. This, however, presents only a limited cost, as the acceleration of payments is only triggered by improvement in the terms of trade, leading to increased repayment capacity.

We have discussed the results of the scheme on the basis of a preferred parameter selection. Other choices give different results and show the high sensitivity of a scheme of this sort to the triggers and repayment proportions employed. Summary results from five different alternative sets of parameters are presented in Table 6.

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[8] The NPV gain to country *j* is ΔNPV_j and country *j*'s base period debt service is DS_j. Because the same discount rate is used for all countries and for the total impact on the lender, the total absolute NPV gain to the borrowers equals the aggregate absolute NPV loss to the lender. The total NPV loss to the lenders can be expressed as $-\sum_{j=1}^{n} \Delta NPV_j$ where *n* is the number of participating borrowers.

Expressed as a ratio to base period debt service, the aggregate loss is $Loss = -\frac{\sum_{j=1}^{n} \Delta NPV_j}{\sum_{j=1}^{n} DS_j}$. We can write this as: $Loss = -\sum_{j=1}^{n} w_j \frac{\Delta NPV_j}{DS_j} = -\sum_{j=1}^{n} w_j Gain_j = -Weighted\_Gain$ where the weights are the shares of the country's base period debt service in total base period debt service: $w_j = -\frac{DS_j}{\sum_{i=1}^{n} DS_i}$. So the loss to the creditors is minus the weighted gains to the borrowers where the weights are the shares of the country's base period debt service in total base period debt service.

6 Financing

The structure outlined above would introduce significant cashflow variability into the repayment scheme received by the lender but with the property that the total repayments received over time (of their NPV in the discounted scheme) would be unaffected. Indeed, total repayments might even be marginally improved if the scheme reduces the default rate. In this section we briefly outline how the lender might offset this timing variability.

Many loans to low income countries have long maturities and this works against direct hedging of the variability using traded derivative markets which are better suited to hedging uncertainty on a period of months or at most a few years ahead. Moreover, hedging using exchange derivatives would fail to take advantage of the fact that the cashflow uncertainty relates only to timing and not to the overall value of the repayments. In our opinion, hedging would be much more effectively carried out using an OTC ("over the counter") swap in which the lender would exchange its floating cashflow for a fixed cashflow through an investment bank. The structure of the transaction is that the investment bank would receive the variable cashflows S_t , $t = 1, \ldots, T$, and would pay the lender the scheduled cashflows S_t^*, $t = 1, \ldots, T^*$. It would charge an annual fee to cover its costs and profit margin. In this arrangement, it would be a matter for the investment bank to determine if and how it chooses to hedge the uncertainty it has assumed, but that issue would cease to be a concern for the lender.

7 Conclusion

We investigated, using Monte Carlo simulations, the possible mode of operation of an implementable scheme for introducing flexibility into debt service on the basis of fluctuations of borrowers' terms-of-trade. We designed an instrument that revises the repayments in a way that is easier for the debtor to meet. We defined country-specific indices which are comparable across LICs so that, based on the value of their indices, all debtor countries are treated in an identical manner and which is directly interpretable in terms of other economic variables. The instrument adjusts debt service proportionally to the deviation of the country-specific index relative to its moving average from the preceding four year.

Modifications of this sort appear feasible. The flexibility of low income primary producing countries is increased by the augmentation of debt service obligations by postponement and acceleration. Commodity-dependent LICs employing this instrument would be able to adjust debt service payments between periods of positive and negative shocks, and thus would be able to better utilize scarce fiscal resources. Participating countries would be able to avoid excessively high ratios of concessional debt service to export revenue. We estimate that the average reduction of incidences with high debt service to exports ratio due to the scheme is 5.5%. The only cost the borrower can potentially face is the loss of concessionality due to acceleration of payments in the event of a positive shock. However, the weighted gain to the borrowers in terms of reduction of the expected repayment stream in NPV terms is 0.5% percent of the non-indexed stream. Simulation results show that the average gain to countries which would see a decline in NPV of debt due to the scheme is 8.3%, while the average loss to countries for which the NPV of debt would increase under the scheme is only 3.8%. The benefits of the instrument are restricted to countries heavily dependent on primary commodity exports or import of major commodities such as energy sources and grains.

The design of the instrument allows for timely intervention in the event of terms of trade shocks and avoids moral hazard. The index that guides the changes in debt service is based on deviations of international commodity prices from their moving average trends. These are known with certainty by the end of the year in question, and can be accurately estimated during the course of the year on the basis of partial information. In relation to moral hazard, no low-income country is sufficiently important in the world market for these commodities to be able to influence the world price.

We find that the instrument imposes only minor costs on the lender. Simulation of a portfolio of conventional concessional credits and a similar portfolio of credits indexed to commodity prices shows that the latter results in a comparative loss to the creditor of about 0.5 percent of total re-flows in expected net present value terms relative to the benchmark of full and timely repayment. The main risk that the lender faces is the cash flow uncertainty that arises from the resulting repayment variability.

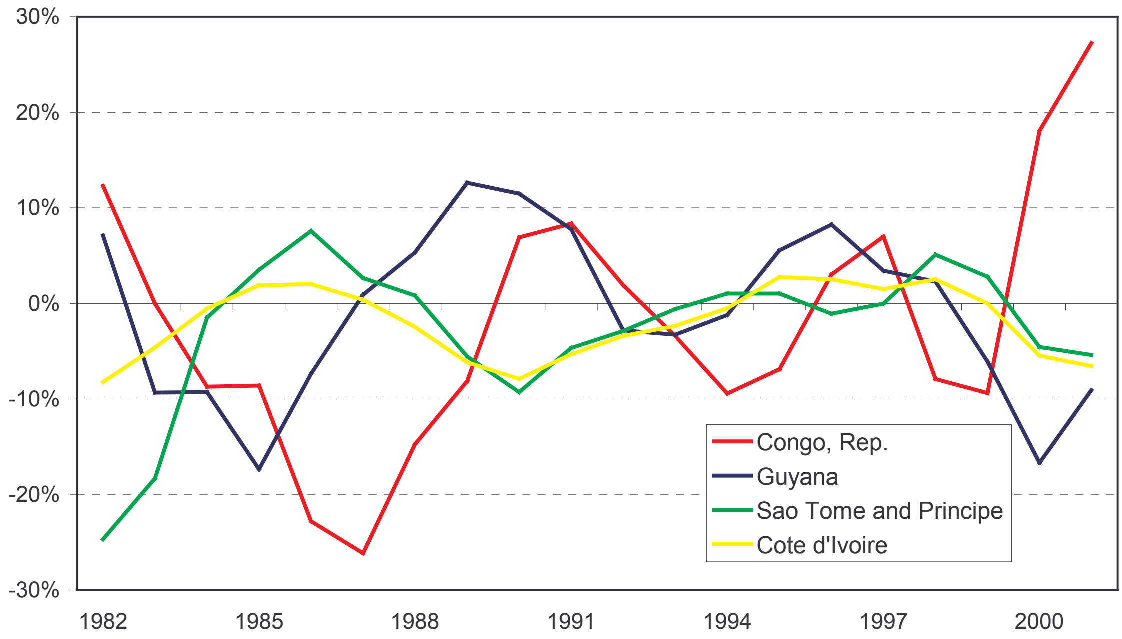

Figure 3: Index Values 1982-2001, Four High Volatility Countries

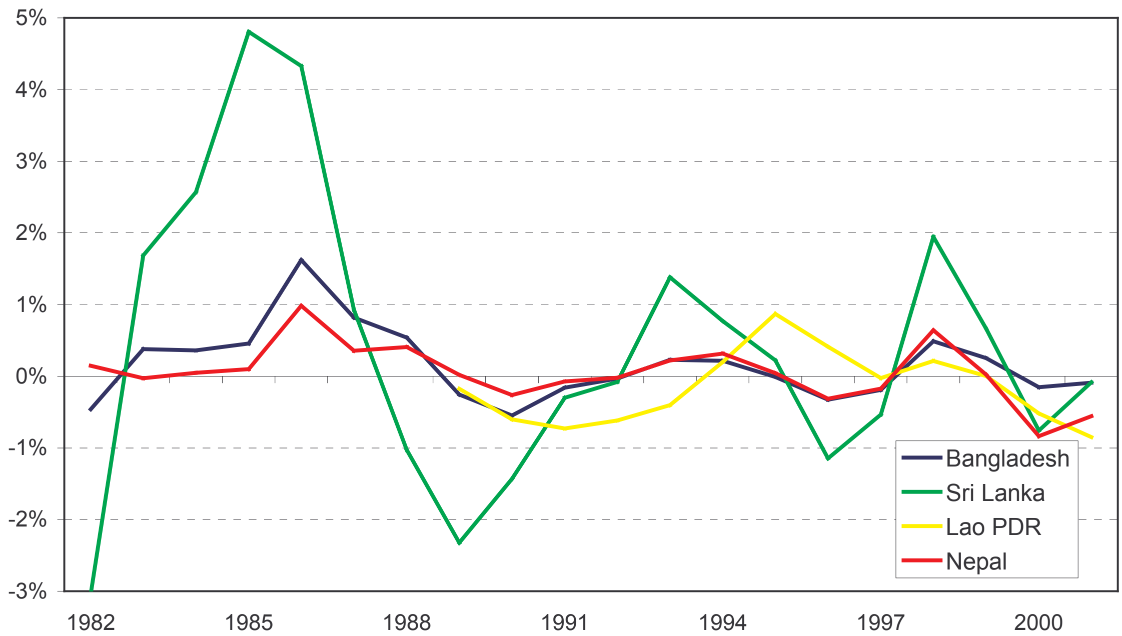

Figure 4: Index Values 1982-2001, Four Asian Countries

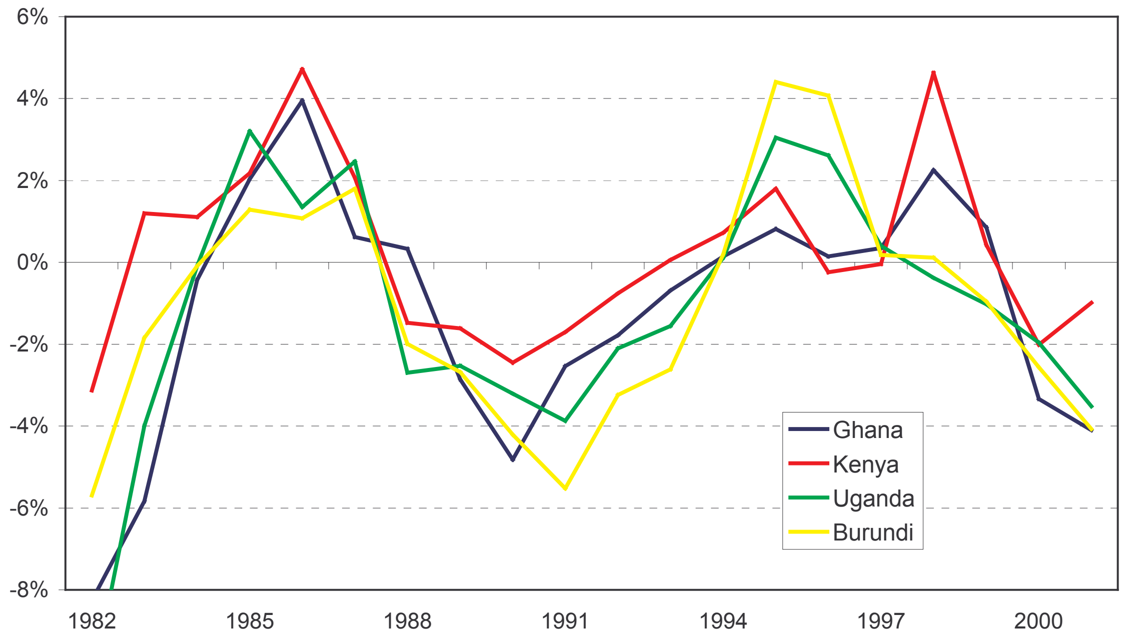

Figure 5: Index Values 1982-2001, Four African Countries

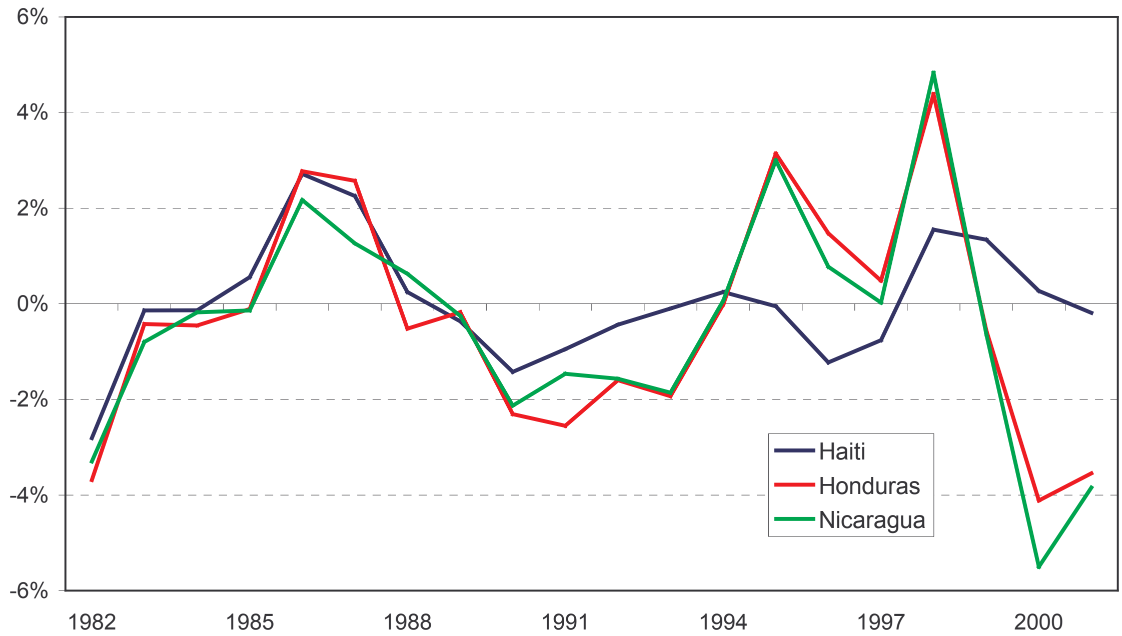

Figure 6: Index Values 1982-2001, Three Latin American and Caribbean Countries

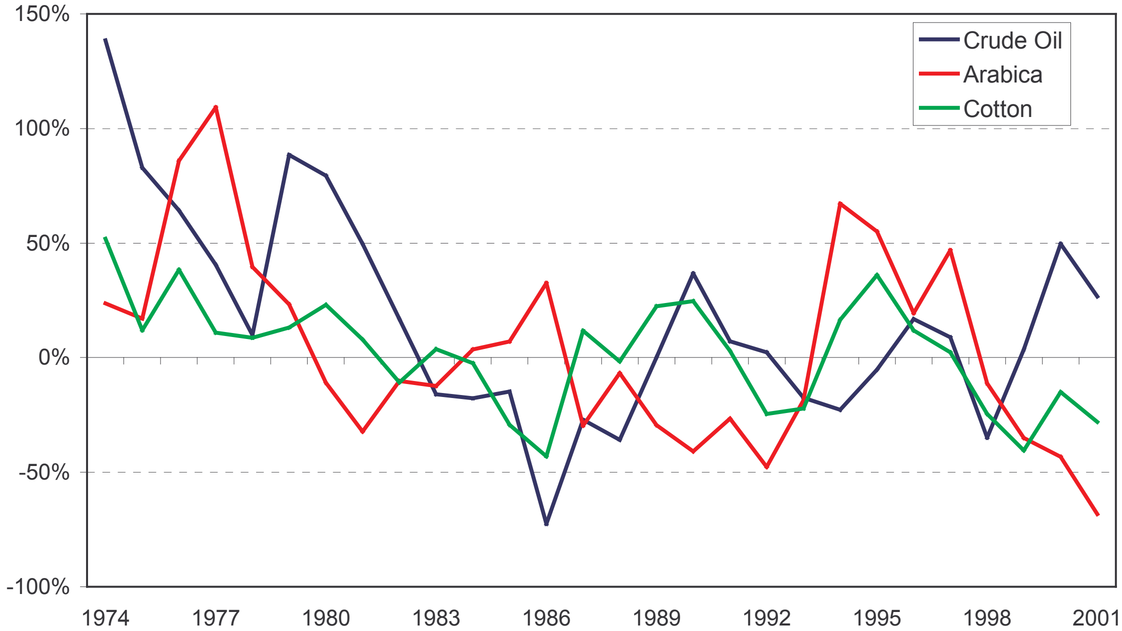

Figure 7: Historic price volatility of crude oil, coffee and cotton (1974-2001)

Table 2

Index Summary Statistics (1983-2001, except where stated)

Country	Start	Average	s.d.	Max	Min
Congo, Rep.		-2.83%	12.98%	27.25%	-26.16%
Guyana		-1.31%	8.85%	12.61%	-17.36%
Tajikistan	1997	-4.00%	7.81%	6.86%	-14.47%
Moldova	1997	-5.10%	7.26%	3.41%	-14.89%
Yemen, Rep.	1995	1.67%	6.60%	12.03%	-4.71%
Sao Tome & Principe		-1.54%	5.80%	7.59%	-18.31%
Cote d'Ivoire		-1.66%	3.53%	2.76%	-7.88%
Mauritania		0.66%	3.26%	6.81%	-5.40%
Cameroon		-1.86%	2.89%	1.76%	-8.43%
Georgia	1998	-0.30%	2.84%	3.34%	-3.21%
Kyrgyz Republic	1997	-1.79%	2.75%	1.84%	-5.46%
Ethiopia	1998	-0.61%	2.71%	3.12%	-2.68%
Burundi		-0.88%	2.71%	4.40%	-5.52%
Ghana		-0.78%	2.57%	3.95%	-5.84%
Uganda		-0.72%	2.40%	3.20%	-3.99%
Sierra Leone		0.24%	2.38%	5.01%	-4.90%
Nicaragua		-0.30%	2.32%	4.83%	-5.50%
Honduras		-0.18%	2.28%	4.38%	-4.11%
Liberia		-0.30%	2.10%	4.65%	-3.66%
Kenya		0.40%	2.05%	4.71%	-2.45%
Senegal		0.88%	1.92%	7.11%	-1.21%
Guinea-Bissau		0.52%	1.90%	4.96%	-2.66%
Sri Lanka		0.61%	1.86%	4.81%	-2.32%
Solomon Islands		0.44%	1.76%	5.71%	-2.76%
Djibouti	1996	-0.42%	1.76%	2.56%	-1.98%
Mongolia	1998	-0.02%	1.72%	2.15%	-1.63%
Togo		-0.41%	1.69%	2.69%	-3.68%
Gambia		0.64%	1.45%	3.82%	-1.78%
Rwanda		-0.21%	1.45%	2.12%	-3.15%

Country	Start	Average	s.d.	Max	Min
Tonga		0.43%	1.35%	4.17%	-1.51%
Madagascar		-0.17%	1.29%	2.46%	-2.25%
Comoros	1985	0.51%	1.27%	3.69%	-1.22%
Mali		0.00%	1.26%	2.00%	-3.08%
Tanzania	1993	0.11%	1.26%	2.23%	-1.63%
Zambia		0.36%	1.19%	3.58%	-2.17%
Benin		-0.39%	1.11%	1.13%	-3.61%
Haiti		0.18%	1.10%	2.71%	-1.42%
Chad		-0.14%	1.08%	1.36%	-2.69%
Vietnam	1990	-0.30%	1.06%	1.37%	-1.84%
Samoa	1989	-0.29%	1.04%	1.21%	-2.45%
Vanuatu		0.20%	0.99%	2.74%	-1.60%
Mozambique	1985	0.10%	0.96%	2.34%	-1.49%
Central African Rep.		-0.32%	0.82%	0.91%	-1.63%
Malawi		-0.27%	0.75%	1.48%	-1.35%
Bhutan	1996	0.00%	0.71%	0.99%	-0.92%
Niger		0.26%	0.69%	2.31%	-0.63%
Eritrea	1999	0.53%	0.67%	1.28%	-0.01%
Sudan		0.23%	0.63%	1.85%	-1.08%
Congo, Dem. Rep.		-0.24%	0.62%	0.48%	-1.55%
Cape Verde	1991	0.09%	0.61%	0.77%	-1.09%
Lao PDR	1989	-0.17%	0.51%	0.87%	-0.85%
Burkina Faso		0.22%	0.51%	1.39%	-0.42%
Bangladesh		0.19%	0.49%	1.62%	-0.55%
Nepal		0.05%	0.41%	0.98%	-0.84%
Guinea	1991	-0.04%	0.37%	0.61%	-0.47%
Cambodia	1992	-0.11%	0.28%	0.26%	-0.59%
Median		*-0.30%*	*2.38%*	*4.38%*	*-3.99%*

Table 5
Simulation Summary Statistics

	Activity	Years with High Debt Service to Export Ratios	Arrears after 25 Years (in % of Initial Debt Stock)				Arrears after 15 years (in % of Initial Debt Stock)			
	Average Incidence	Reduction	Average	st. dev.	95% point	99% point	Average	st. dev.	95% point	99% point
Concesionary Loans			4.4%	1.4%	6.7%	7.7%	-0.1%	1.1%	1.8%	2.5%
Congo, Rep.	96.5%	45.7%	37.9%	12.8%	59.1%	67.5%	24.1%	10.5%	42.2%	50.7%
Yemen, Rep.	91.1%	1.6%	31.8%	11.6%	51.5%	59.0%	20.6%	9.7%	36.5%	42.9%
Kyrgyz Rep.	80.1%	17.6%	0.4%	1.5%	2.6%	7.9%	-6.3%	6.0%	3.5%	8.7%
Sierra Leone	77.6%	9.6%	0.3%	1.5%	1.8%	8.3%	-7.7%	6.6%	3.7%	9.2%
Burundi	77.1%	12.4%	8.6%	6.3%	20.3%	24.5%	4.7%	5.8%	14.9%	18.1%
Nicaragua	76.9%	-4.1%	5.7%	5.1%	15.6%	19.3%	2.7%	5.2%	11.0%	14.7%
Honduras	75.4%	-3.4%	8.7%	5.6%	18.3%	23.1%	5.2%	5.0%	13.5%	17.3%
Cameroon	71.8%	23.1%	19.3%	9.0%	34.6%	40.7%	12.7%	7.7%	25.4%	30.5%
Mongolia	71.5%	-0.2%	0.2%	0.9%	0.0%	4.8%	-7.7%	5.4%	1.9%	5.7%
Ghana	67.3%	0.0%	1.2%	2.5%	7.1%	11.2%	-2.4%	4.6%	6.1%	9.1%
Uganda	66.7%	-0.3%	3.6%	4.0%	11.0%	15.0%	1.8%	4.3%	9.0%	12.0%
Senegal	66.0%	-0.3%	0.0%	0.4%	0.0%	1.0%	-9.0%	4.9%	-1.0%	3.1%
Kenya	64.8%	-0.1%	1.9%	2.9%	8.0%	12.1%	0.0%	4.1%	7.0%	10.1%
Benin	62.9%	14.3%	0.9%	1.8%	4.9%	7.8%	-1.9%	3.4%	3.9%	6.8%
Zambia	52.4%	8.4%	0.0%	0.2%	0.0%	1.0%	-5.1%	2.8%	0.0%	2.1%
Sri Lanka	51.5%	0.0%	0.1%	0.7%	1.1%	3.2%	-3.1%	3.2%	2.1%	4.2%
Vietnam	50.3%	-0.4%	7.0%	4.9%	15.9%	19.1%	4.2%	4.1%	11.1%	14.3%
Madagascar	48.1%	-0.3%	0.0%	0.1%	0.0%	0.0%	-7.0%	2.9%	-2.0%	0.0%
Samoa	47.9%	0.0%	0.0%	0.1%	0.0%	0.0%	-7.1%	3.1%	-2.1%	0.0%
Haiti	46.3%	2.2%	0.0%	0.0%	0.0%	0.0%	-7.1%	3.0%	-2.0%	0.0%
Malawi	45.8%	8.9%	0.1%	0.4%	0.0%	2.0%	-3.4%	2.6%	1.0%	3.0%
Burkina Faso	40.4%	6.9%	0.0%	0.0%	0.0%	0.0%	-5.7%	2.0%	-2.0%	-1.0%
Niger	37.8%	-2.2%	0.0%	0.0%	0.0%	0.0%	-5.6%	2.5%	-2.0%	0.0%
Rwanda	36.9%	9.2%	0.0%	0.0%	0.0%	0.0%	-4.9%	2.2%	-1.0%	0.0%
Nepal	35.8%	-1.7%	0.0%	0.0%	0.0%	0.0%	-5.4%	2.5%	-1.0%	0.0%
Tanzania	35.2%	0.0%	0.0%	0.1%	0.0%	0.0%	-4.2%	2.2%	-1.0%	1.0%
Mozambique	33.3%	9.3%	0.0%	0.0%	0.0%	0.0%	-7.3%	3.2%	-3.0%	-1.5%
Lao PDR	31.9%	7.6%	0.0%	0.0%	0.0%	0.0%	-4.3%	2.0%	-1.0%	0.0%
Bhutan	31.8%	0.1%	0.0%	0.0%	0.0%	0.0%	-4.5%	2.3%	-0.9%	0.0%
Congo, DR	20.4%	5.2%	0.0%	0.2%	0.0%	1.1%	-2.4%	2.1%	0.0%	2.1%
Bangladesh	17.4%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.4%	1.8%	0.0%	0.0%
Average	*55.1%*	*5.5%*	*4.1%*	*2.3%*	*8.1%*	*10.6%*	*-1.2%*	*4.1%*	*5.6%*	*8.5%*

Table 6
Simulation Summary Statistics

		A	B	C	D	E
Triggers	Lower outer	- 1.50%	- 2.50%	- 2.00%	- 2.00%	- 1.50%
	Lower inner	- 0.75%	- 1.25%	- 1.50%	- 1.50%	- 0.75%
	Upper inner	0.50%	0.50%	0.50%	0.50%	0.50%
	Upper outer	1.00%	1.00%	1.00%	1.00%	1.00%
Repayment Percentage	Lower outer band	0%	0%	0%	0%	0%
	Lower inner band	50%	50%	50%	50%	50%
	Central band	100%	100%	100%	100%	100%
	Upper inner band	125%	125%	125%	133%	150%
	Upper outer band	150%	150%	150%	167%	200%
Average usage		60.8%	55.1%	53.0%	54.3%	63.9%
(standard deviation)		(9.3%)	(9.3%)	(9.2%)	(9.4%)	(9.6%)
Average reduction in years with high debt service-export ratios		6.5%	5.5%	4.4%	4.6%	4.8%
Arrears after 15 years	Average	4.2%	- 0.1%	0.0%	- 2.6%	- 3.5%
	(st. dev.)	(1.5%)	(2.1%)	(1.2%)	(1.4%)	(2.1%)
	95% point	6.7%	1.8%	2.0%	- 0.4%	- 0.1%
	99% point	7.7%	2.5%	2.8%	0.5%	1.2%
Final arrears (25 years)	Average	7.6%	4.4%	4.8%	3.4%	3.9%
	(st. dev.)	(1.9%)	(2.0%)	(1.5%)	(1.5%)	(2.0%)
	95% point	12.1%	6.7%	7.2%	6.0%	6.9%
	99% point	13.4%	7.7%	8.3%	7.0%	8.4%

Econometric Appendix

Indices are simulated for each country in each year as a product of the simulated commodity prices and a constant 2001-base 4-year moving average commodity exports and imports weights. The commodity prices are calculated using a standard error correction model:

$$\Delta \ln p_{jt} = \beta_{j0} + \beta_{j1} t + \beta_{j2} \Delta \ln p_{j,t-1} + \beta_{j3} (\ln p_{j,t-2} - \ln \pi_{t-2}) + u_{jt} \quad (1)$$

where π_t is the US producer price index. The equations for Arabica coffee, maize, rice, wheat, coal, and natural gas contain additional terms specifying interactions with other commodities. These equations have the following form:

$$\begin{aligned} \Delta \ln p_{jt} &= \beta_{j0} + \beta_{j1} t + \beta_{j2} \Delta \ln p_{j,t-1} + \beta_{j3} (\ln p_{j,t-2} - \ln \pi_{t-2}) \\ &+ \beta_{j4} \Delta \ln p_{k,t-1} + \beta_{j5} (\ln p_{k,t-2} - \ln \pi_{t-2}) + u_{jt} \end{aligned} \quad (2)$$

where p_{kt} is the price of substitute commodity k in year t. The substitute commodities are as specified in Table A1:[9]

Table A1
Commodity Price Specifications

Commodity	Substitute Commodity
Arabica coffee	Robusta coffee
Maize	Wheat
Rice	Wheat
Wheat	Rice
Coal	Crude oil
Natural gas	Crude oil

The table shows the substitute commodities (column 2) *k* corresponding to each commodity *j* in relation to equation (2).

The eleven agricultural commodity price equations are estimated as a system using Three Stage Least Squares (3SLS) over the sample 1972-2001. Estimation results (*t* values in parentheses) are given in Table A2. The three energy price equations are also estimated as a system, together with the supplementary (first order autoregressive) equation for the U.S. producer price index, again using 3SLS, over the shorter sample 1979-2001. The use of the shorter sample is forced by lack of coal price data back to 1970. Estimation results are reported in Table A3.

[9] The choice of substitute commodities was entirely empirical and without regard to Slutsky symmetry, either in terms of inclusion or the magnitude of the coefficient.

We consider two routes by which changes in commodity prices affect economic growth (where growth here may be seen as a place-holder for the entire range of development objectives).

- Direct effects: high export prices and low import prices make governments and commodity producers better off allowing higher real consumption and greater investment, and make consumers worse off in a symmetric manner.
- Indirect effects: higher export earnings and/or lower import expenditure requirements relax the budget constraints facing government and firms.

We investigate the indirect link in two stages. We first show how variations in the index translate into what we call free foreign exchange, and then investigate whether the availability of free foreign exchange affects economic growth. A rise (fall) in export prices or a fall (rise) in import prices increases (decreases) the amount of foreign exchange available to the country for other purposes. If changes in local prices were completely in line with changes in world prices, and if there were no production or consumption responses to these price changes, the impact on free foreign exchange availability should be one-to-one. The second stage in the argument is to link free foreign exchange to growth. The implicit model here is one in which low income countries are constrained in their access to foreign exchange. If there is such a link, it can be moderated by appropriate variation of debt service payments.

We estimate the growth relationship using panel regression methodology.

- We regress growth on free foreign exchange availability (indirect effect) and the commodity price indices (direct effect).
- In order to complete the indirect link, we regress free foreign exchange availability on the commodity price indices.

Country j's free foreign exchange availability in year t is measured as $z_{jt} = \frac{X_{jt} - M_{jt}}{Y_{jt}}$ where X_{jt} is the US dollar value of the country's total exports in year t, M_{jt} is the US dollar value of the country's energy and grains imports in year t and Y_{jt} is the US dollar value of the country's GDP. In the second set of regressions, we use a modified definition of availability which takes concessional debt service into account: $\zeta_{jt} = \frac{X_{jt} - M_{jt} - S_{jt}}{Y_{jt}}$ where S_{jt} is the US dollar value of the country's total concessional debt service in year t.[10] In many countries,

[10] Source: World Bank.

both variables exhibit strong trends and so, for compatibility with the definition of the price indices, we measure these variables relative to their four year moving averages: $\tilde{z}_{jt} = z_{jt} - \frac{1}{4}\sum_{i=1}^{4} z_{j,t-i}$ and $\tilde{\zeta}_{jt} = \zeta_{jt} - \frac{1}{4}\sum_{i=1}^{4} \zeta_{j,t-i}$. The two concepts are related by the equation

$$\zeta_{jt} = z_{jt} - \frac{S_{jt}}{Y_{jt}} \tag{3}$$

Consider the growth equations first. Letting g_{jt} be country *j*'s annual rate of growth of real GDP in year *t*, our basic model is

$$g_{jt} = \beta_0 + \beta_1 \tilde{\zeta}_{jt} + \beta_2 \ln q_{jt} + \beta_3 IPG_{t-1} + \beta_4 WTG_{t-1} + \mu_j + e_{jt} \tag{4}$$

Here, IPG_{t-1} is the rate of growth of industrialized countries' industrial production in the previous year and WPG_{t-1} is the rate of growth of world trade in the previous year (both variables are common across all countries).[11] μ_j is a country effect and e_{jt} is an independently distributed disturbance. This specification allows growth to depend both on free foreign exchange and on the level of the commodity price index, together with a common world trade trend. (The lag structure was suggested by preliminary regressions).

The growth specification in equation (4) differs from that used in much of the empirical growth literature in two respects:

- We measure growth on an annual basis whereas it is more convention to aggregate to four or five year "epochs". That procedure may be criticized as arbitrary and it also substantially reduces the number of degrees of freedom.
- We include a set of country effects forcing estimation in differences. This precludes examination of the effects of slowly changing variables, such as indices of institutional quality, on growth since these are washed out through the difference transformation. Although this may result in some loss of precision, it avoids the possibility that the results are dependent on the particular set of control variables included in the regression.

[11] World trade is measured by the average of the US dollar values of total world exports plus total world imports deflated by the US Producer Price index (all items). Source for variables: IMF, *International Financial Statistics*.

The growth equation (4) provides a basic structure within which we can explore a number of variants of the same specification. We consider two specific variants. First, the overall price indices $\ln q_{j,t-1}$ may be considered as aggregating across a set of sub-indices covering

- agricultural export prices
- metals export prices
- energy export prices
- grain import prices
- energy import prices

We investigate whether the impact of price changes is uniform across these categories. Second, we consider whether positive and negative values of the commodity price index (or indices) have symmetric effects.

Estimation of growth equations on panel datasets is often problematic because, with relative short time dimension, it is inappropriate to condition on lagged dependent variables. This is not a problem for our model since we not expect lagged dependence, and in any case, the maximum time dimension available for estimation of 26 years is not low. Furthermore, the commodity price indices $\ln q_{jt}$ may be taken as exogenous since the country-specific feature of these indices relates only to the weighting of a common set of prices determined on world markets. This suggests that pooled Ordinary Least Squares (OLS) estimation of the differenced versions of equations (4) and (5) should be consistent.[12] Consistency is brought into question however, by the possible endogeneity of the free foreign exchange variable $\tilde{\zeta}_{jt}$ in equation (2) suggests that this equation might be estimated by Generalized Method of Moments (GMM).[13] If the pooled OLS estimates are consistent they should be more efficient (hence more precisely determined) than the GMM estimates. The GMM estimates will be consistent on a much less restrictive set of assumptions.

Turning to the indirect channel, we model free foreign exchange availability by modeling the export to GDP ratio and the ratio of energy and grains imports to GDP. This allows us to obtain the variables z_{jt} and ζ_{jt} by construction, and hence also their deviations from the four year moving average. In both cases, we specify the relationship as a partial adjustment to

[12] Differencing eliminates the country-specific components μ_j and ν_j.
[13] We use the DPD module of the GiveWin package and estimate in differences. We only report the first stage GMM estimates. *t* statistics are based on heteroscedasticity-robust standard errors.

current and lagged prices. In the export equation we condition on the agricultural and energy export price indices while in the import equation we condition on the energy and grains import price sub-indices. In both cases, the dependent variable is in logarithms to prevent negative ratios in the simulation experiments (there is never any problem with exports or imports exceeding GDP).

The specification of the export to GDP ratio is

$$\begin{aligned} \ln\left(\frac{X_{jt}}{Y_{jt}}\right) &= \gamma_0 + \gamma_1 z \ln\left(\frac{X_{j,t-1}}{Y_{j,t-1}}\right) + \gamma_{20}\Delta \ln q^{ax}_{jt} + \gamma_{21} \ln q^{ax}_{j,t-1} \\ &+ \gamma_{30}\Delta \ln q^{ex}_{jt} + \gamma_{31} \ln q^{ex}_{j,t-1} + \gamma_5 \Delta IPG_t + \nu^x_j + \varepsilon^x_{jt} \end{aligned} \tag{5}$$

Analogously, the equation for energy and grains imports is specified as

$$\begin{aligned} \ln\left(\frac{M_{jt}}{Y_{jt}}\right) &= \gamma_0 + \gamma_1 z \ln\left(\frac{M_{j,t-1}}{Y_{j,t-1}}\right) + \gamma_{20}\Delta \ln q^{em}_{jt} + \lambda_{21} \ln q^{em}_{j,t-1} \\ &+ \gamma_{30}\Delta \ln q^{gm}_{jt} + \gamma_{31} \ln q^{gm}_{j,t-1} + \gamma_5 \Delta IPG_t + \nu^m_j + \varepsilon^m_{jt} \end{aligned} \tag{6}$$

Pooled OLS estimates of the symmetric response version of equation (5) are given in Table A4. Column A relates to the basic specification. Experimentation indicated that agricultural export prices affect growth with a one year lag while the impact of energy export prices and grain import prices is spread over the current and succeeding year. The (indirect impact) coefficient β_2 associated with the commodity price index is small and poorly determined. This difference may reflect differences in the commodity composition of exports and imports or contracting arrangements (forward sales, delivery lags etc.).

We investigate the relationship further by disaggregation. We define separate indices for agricultural export price $\ln q^{ax}$, metals prices $\ln q^{mx}$, energy export prices $\ln q^{ex}$, energy import prices $\ln q^{em}$ and grains import prices $\ln q^{gm}$. The energy export and grain import prices are averaged over the current and succeeding year. The estimates, reported in column B, show broadly similar coefficients for each group, with the exception of metals, although only the coefficient of energy exports is precisely determined. As noted, however, the coefficient associated with metals export prices is incorrectly signed. This remains true even if the variable is unlagged. This motivates recomposition of the index in line with the estimated coefficients as discussed in the main text.

This gives a more precisely determined equation. The (one stage) GMM estimates are similar to the pooled OLS estimates but give greater weight to the indirect impact of price changes through the free foreign exchange variable $\tilde{\zeta}_{jt}$. As noted above, it is this variable which is the potential cause of conditioning problems in estimation.[14]

Table A5 reports the results of investigations into possible asymmetries in the growth relationship. The first column of the table repeats the pooled OLS estimates from the third column of Table A4. In the second column, we estimate separate coefficients for positive and negative values of the commodity price index. The coefficient associated with negative index suggests that while positive terms of trade movements lead to faster growth, negative movements are not harmful. However, a *t* test for the asymmetry shows the difference to be insignificant (t = 1.42). There is therefore no strong evidence of asymmetry in these responses.

An alternative possibility is that the effects of persistently low export prices depress investment and that this feeds through into lower growth only with a time lag. This is investigated in specification E. There is evidence of such an effect with a three year lag for agricultural export prices but no such evidence for energy prices. The specification reported in the table (columns 3 and 4) is

$$g_{jt} = \beta_0 + \beta_1 \tilde{\zeta}_{jt} + \beta_{21} \ln q_{j,t-1} + \beta_{22} \max\left(\ln q^{ax}_{j,t-3}, 0\right) + \beta_3 IPG_{t-1} + \beta_4 WTG_{t-1} + \mu_j + e_{jt} \tag{7}$$

The estimates in the final column of Table A4 are therefore our preferred estimates. The estimated asymmetric response, measured by the coefficient β_{22}, is large, but is only statistically significant in the pooled OLS estimates. However, since both the estimated β_2 GMM coefficients are very close to the pooled OLS coefficients, there is no reason to distrust the OLS estimate of this impact, even through the actual coefficient value is imprecisely determined.

Table A6 lists the observations used for the specification E estimates in Table A5. The longest sample is 19 years (1983-2001) and this full sample is available for 19 countries. Table A6 also reports the R^2 coefficients for each country sub-sample from the pooled OLS

[14] We also investigated whether there is lagged dependence in the growth relationship. The pooled OLS estimates give highly significant coefficients on the lagged growth variable, but it is well known that estimates of this coefficient can be very biased on panels with short time dimension. This was confirmed by GMM estimates which allow acceptance of the hypothesis of no lagged dependence.

estimates (Table A6, column 3). Among countries with ten or more observations available, the explanation is best in Zambia (R^2 = 0.36) followed by the Congo Republic (R^2 = 0.24), Haiti (R^2 = 0.23) and St. Vincent and the Grenadines (R^2 = 0.20). A number of (mainly Asian) countries show large negative R^2 values, most notably Bangladesh, Bhutan, the Lao P.D.R. and Sri Lanka. However, exclusion of these countries made very little difference to the estimates and we therefore decided to remain with the complete available sample.[15]

Finally, in Table A7, we report the estimates of the supplementary equations (5) and (6) used in construction of free foreign exchange variability. Specification F (column 1) uses the same definition of the commodity prices indices $\ln q_{jt}$ as in the growth equation reported in Table A4. Specification G (column 2) uses a modified definition in which export prices and oil import prices are unlagged but grain import prices are lagged one year. As previously, metals prices are excluded. Because pooled OPLS estimates will be badly biased in the presence of the lagged dependent variable, we report only the GMM estimates. The estimates associated with specification G are much more precise in relation to the coefficients of the commodity price index, and we therefore adopt this specification.

The model also requires equations for the change in industrial production in the industrialized countries *IPG* and growth in world trade *WTG*.[16] Since the objective is that of generating shocks rather than to offer any explanation of the variables, we adopt autoregressive structures. The two equations were estimated as a system using 3SLS over the sample 1976-2001. The estimated equations (t values in parentheses) are:

$$WTG_t = \underset{(2.15)}{0.029} + \underset{(2.29)}{0.336} WTG_{t-1} \qquad (8)$$
$$s.e. = 0.0608$$

and

$$IPG_t = \underset{(4.65)}{0.026} - \underset{(1.30)}{0.161} IPG_{t-2} \qquad (9)$$
$$s.e. = 0.0264$$

[15] The estimates also show two very large residuals associated with the civil war in Rwanda in 1994 and 1995.Howver, the observations have negligible leverage.
[16] Date sources: IMF, *International Financial Statistics*. World Trade is the sum of total imports and total exports of the industrialized countries.

Table A2
Estimated Agricultural Price Equations
(Dependent variable $\Delta \ln p_{jt}$)

	β_{j0} intercept	β_{j1} trend	β_{j2} $\Delta \ln p_{j,t-1}$	β_{j3} $\ln p_{j,t-2} - \ln \pi_{t-2}$	β_{j4} $\Delta \ln p_{k,t-1}$	β_{j5} $\ln p_{k,t-2} - \ln \pi_{t-2}$	s.e.
Cocoa	4.149 (6.15)	-0.0292 (5.42)	-0.158 (1.32)	-0.465 (5.93)	-	-	0.1959
Coffee (arabica)	6.707 (7.49)	-0.1632 (2.37)	-1.048 (7.37)	-1.651 (8.22)	0.466 (2.90)	0.895 (4.79)	0.2594
Coffee (robusta)	5.383 (5.81)	-0.0372 (4.97)	-0.207 (1.60)	-0.595 (5.65)	-	-	0.2891
Cotton	5.733 (4.48)	-0.0284 (4.63)	-0.557 (4.16)	-0.677 (4.36)	-	-	0.1912
Maize	2.488 (3.61)	-0.0215 (4.35)	-1.015 (7.00)	-1.098 (6.71)	0.754 (4.63)	0.651 (3.79)	0.1510
Rice	3.803 (4.68)	-0.0280 (4.60)	-0.283 (1.95)	-0.959 (5.78)	0.119 (0.57)	0.462 (1.91)	0.2241
Natural rubber	5.393 (6.80)	-0.0224 (5.13)	-0.335 (3.41)	-0.680 (6.62)	-	-	0.1853
Soybeans	4.829 (5.73)	-0.0309 (5.63)	-0.473 (3.82)	-0.722 (5.58)	-	-	0.1643
Sugar	4.249 (4.51)	-0.0352 (3.23)	-0.265 (1.71)	-0.632 (4.44)	-	-	0.3877
Tea	5.784 (4.20)	-0.0211 (3.68)	-0.715 (5.18)	-0.697 (4.14)	-	-	0.1900
Wheat	3.867 (6.87)	-0.0235 (5.64)	-0.475 (3.96)	-0.832 (6.54)	0.317 (5.29)	0.166 (2.42)	0.1458

The eleven equations are estimated as a system using 3SLS over the sample 1972-2001. t statistics are given in parentheses. The suffix *j* relates to the own price and *k* to the price of the alternative commodity – see text and Table A1.

Table A3
Estimated Energy Price Equations
(Dependent variable $\Delta \ln p_{jt}$)

	β_{j0} intercept	β_{j1} trend	β_{j2} $\Delta \ln p_{j,t-1}$	β_{j3} $\ln p_{j,t-2} - \ln \pi_{t-2}$	β_{j4} $\Delta \ln p_{k,t-1}$	β_{j5} $\ln p_{k,t-2} - \ln \pi_{t-2}$	s.e.
Coal	3.214 (3.81)	-0.0239 (3.42)	-0.142 (0.91)	-0.795 (4.60)	0.260 (2.92)	0.056 (0.50)	0.1061
Crude oil	2.494 (1.73)	-0.0216 (1.58)	-0.267 (1.32)	-0.382 (1.67)	-	-	0.2807
Natural gas	-3.348 (2.51)	0.0286 (2.33)	-0.723 (3.34)	-0.573 (3.11)	0.552 (2.95)	0.631 (2.81)	0.2057
U.S. Producer Prices	0.0435 (1.62)	-0.0014 (1.28)	0.4592 (2.64)	-	-	-	0.0306

The four equations are estimated as a system using 3SLS over the sample 1979-2001. *t* statistics are given in parentheses. The suffix *j* relates to the own price and *k* to the price of the alternative commodity – see text and Table A1.

Table A4
Estimated Symmetric Growth Equation (2)
Dependent variable g_{jt}

			A	B	C	
	Specification		A	B	C	
	Estimation		Pooled OLS		Pooled OLS	GMM
β_0	Intercept		0.000 (0.64)	- 0.001 (1.69)	- 0.001 (1.64)	- 0.001 (1.38)
β_1	$\tilde{\zeta}_{jt}$		0.091 (1.84)	0.072 (1.53)	0.072 (1.53)	0.136 (2.56)
β_2	$\ln q_{j,t-k}$	*agricultural exports (k=1)*	0.042 (1.14) (k=1)	0.232 (1.10)	0.201 (4.56)	0.141 (1.86)
		grains imports (k=½)		- 0.436 (1.16)		
		energy exports (k=½)		0.208 (5.64)		
		energy imports (k=0)		- 0.106 (0.44)		
		metals exports (k=1)		- 0.106 (0.44)		
β_3	IPG_{t-1}		0.124 (1.13)	0.138 (1.39)	0.137 (1.35)	0.247 (2.08)
β_4	WTG_{t-1}		0.170 (2.37)	0.158 (2.29)	0.160 (2.31)	0.081 (2.19)
σ	standard error		0.0703	0.0693	0.0691	0.0694
AR(1)	N(0,1)		-2.00*	-2.05*	-2.04*	-2.02*
AR(2)	N(0,1)		0.09	- 0.15	0.13	0.05

The estimates in column C omit metals prices from the index. Export prices are lagged one year and import prices are unlagged. A lag of ½ implies an average on the current and one year lagged prices.
A total of 619 observations is used in estimation except in column A (583 observations).
t statistics in parentheses are based on heteroscedasticity-robust standard errors.
The GMM estimates use a single stage procedure where the weighting matrix has units on the diagonal and –½ on the principal sub- and super-diagonal.
AR(1) and AR(2) are respectively N(0,1) tests for first and second order residual serial correlation. An asterix indicates significance at the 5% level. Because estimation is in differences (to eliminate country effects), one should expect negative first order residual serial correlation with these estimates.
GMM instruments:
$\tilde{\zeta}_{j,t-3},...,\tilde{\zeta}_{j,t-5}; \ln q_{jt},..., \ln q_{j,t-5}; IPG_{t-1},...IPG_{t-5}; WTG_{t-1},...WTG_{t-5}$.

Table A5
Estimated Asymmetric Growth Equation (2)
Dependent variable g_{jt}

	Specification		C	D	E	
	Estimation		Pooled OLS		Pooled OLS	GMM
β_0	Intercept		- 0.001 (1.64)	- 0.001 (1.52)	- 0.001 (2.02)	- 0.001 (2.24)
β_1	$\tilde{\zeta}_{jt}$		0.072 (1.53)	0.074 (1.59)	0.066 (1.36)	0.171 (3.38)
β_{21}	$\ln q_{jt}$	*positive*	0.201 (4.56)	0.408 (2.37)	0.216 (5.44)	0.136 (1.91)
		negative		- 0.007 (0.05)		
β_{22}	$\ln q^{ax}_{j,t-3}$	*negative*			0.438 (2.45)	0.464 (1.46)
β_3	IPG_{t-1}		0.137 (1.35)	0.128 (1.26)	0.183 (1.71)	0.279 (2.24)
β_4	WTG_{t-1}		0.160 (2.31)	0.161 (2.30)	0.152 (2.16)	0.059 (1.57)
σ	standard error		0.0691	0.0690	0.0697	0.0702
AR(1)	N(0,1)		-2.04*	-2.05*	-1.98*	-1.97
AR(2)	N(0,1)		0.13	0.12	0.10	- 0.01

A total of 619 observations is used in estimation in columns C and D, and 599 observations in columns E.
t statistics in parentheses are based on heteroscedasticity-robust standard errors.
The GMM estimates use a single stage procedure where the weighting matrix has units on the diagonal and –½ on the principal sub- and super-diagonal.
AR(1) and AR(2) are respectively N(0,1) tests for first and second order residual serial correlation. An asterix indicates significance at the 5% level. Because estimation is in differences (to eliminate country effects), one should expect negative first order residual serial correlation with these estimates. GMM instruments:
$\tilde{\zeta}_{j,t-3},\ldots,\tilde{\zeta}_{j,t-5};\max\left(\ln q^{ax}_{jt},0\right),\ldots,\max\left(\ln q^{ax}_{j,t-5},0\right);\ln q_{jt},\ldots,\ln q_{j,t-5};$
$IPG_{t-1},\ldots,IPG_{t-5};WTG_{t-1},\ldots,WTG_{t-5}.$

Table A6
Growth Estimation Sample

	Obser-Vations	Initial Year	Final Year	R^2
Bangladesh	19	1983	2001	-1.346
Benin	19	1983	2001	0.095
Bhutan	19	1983	2001	-1.559
Bolivia	19	1983	2001	0.079
Burkina Faso	19	1983	2001	0.058
Burundi	2	2000	2001	-0.124
Cameroon	9	1992	2000	0.033
Congo, Dem. Rep.	18	1983	2000	0.118
Congo, Rep.	18	1983	2000	0.236
Dominica	14	1988	2001	-0.124
Ghana	19	1983	2001	-0.121
Haiti	10	1992	2001	0.225
Honduras	13	1988	2000	0.124
India	19	1983	2001	-0.318
Indonesia	19	1983	2001	-0.316
Kenya	17	1983	1999	0.091
Kyrgyz Republic	18	1983	2000	-2.100
Lao PDR	19	1983	2001	-1.121
Madagascar	18	1983	2000	-0.401
Malawi	19	1983	2001	0.142
Mozambique	18	1983	2000	-0.052
Nepal	6	1996	2001	-0.609
Nicaragua	12	1985	1996	0.127
Niger	9	1993	2001	0.245
Nigeria	4	1998	2001	-0.046
Pakistan	15	1983	1997	-0.011
Papua New Guinea	18	1983	2000	0.050
Rwanda	19	1983	2001	-0.107
Senegal	19	1983	2001	0.034
Sierra Leone	19	1983	2001	-0.702
Sri Lanka	19	1983	2001	0.057
St. Lucia	19	1983	2001	0.198
St. Vincent and the Grenadines	2	2000	2001	-1.464
Tanzania	9	1992	2000	-0.126
Uganda	18	1983	2000	-0.586
Vietnam	18	1983	2000	-0.062
Yemen, Rep.	14	1988	2001	0.362
Zambia	19	1983	2001	0.098
Zimbabwe	10	1992	2001	-1.346
Total	*599*			*0.044*

The table lists the growth observations used in the pooled OLS estimation of the specification E reported in Table 4.
The R^2 coefficient gives the proportionate explanation of annual changes in the rate of growth explained by the equation.

Table A7
GMM Estimates of the Supplementary Equations (3) and (4)

	Dependent variable	$\ln\left(\frac{X_{jt}}{Y_{jt}}\right)$	$\ln\left(\frac{M_{jt}}{Y_{jt}}\right)$
γ_0	Intercept	0.008 (4.27)	- 0.002 (0.78)
γ_1	$\ln\left(\frac{X_{j,t-1}}{Y_{j,t-1}}\right), \ln\left(\frac{M_{j,t-1}}{Y_{j,t-1}}\right),$	0.586 (13.9)	0.552 (11.5)
γ_{20}	$\ln q_{jt}^{ax}, \ln q_{jt}^{em}$	-	8.614 (6.25)
γ_{21}	$\ln q_{j,t-1}^{ax}, \ln q_{j,t-1}^{em}$	0.368 (1.62)	- 1.950 (2.75)
γ_{30}	$\ln q_{jt}^{ex}, \ln q_{jt}^{gm}$	0.641 (3.99)	2.147 (1.59)
γ_{31}	$\ln q_{j,t-1}^{ex}, \ln q_{j,t-1}^{gm}$	-	- 3.365 (1.76)
γ_4	IPG_t	1.049 (4.45)	-
σ	standard error observations	0.234 1051	0.351 1034
AR(1) AR(2)	N(0,1) N(0,1)	- 4.52** - 0.67	- 5.44** - 0.78

t statistics in parentheses are based on heteroscedasticity-robust standard errors.
The GMM estimates use a single stage procedure where the weighting matrix has units on the diagonal and –½ on the principal sub- and super-diagonal.
AR(1) and AR(2) are respectively N(0,1) tests for first and second order residual serial correlation. A single asterix indicates significance at the 5% level and a double asterix at the 1% level. Because GMM estimates in differences (to eliminate country effects), one should expect negative first order residual serial correlation with these estimates.
GMM instruments: $IPG_t, ..., IPG_{t-5}$, lagged dependent variable (lags 3-5), price sub-indices (lags 0-5).

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